Advanced Coal Processing Program

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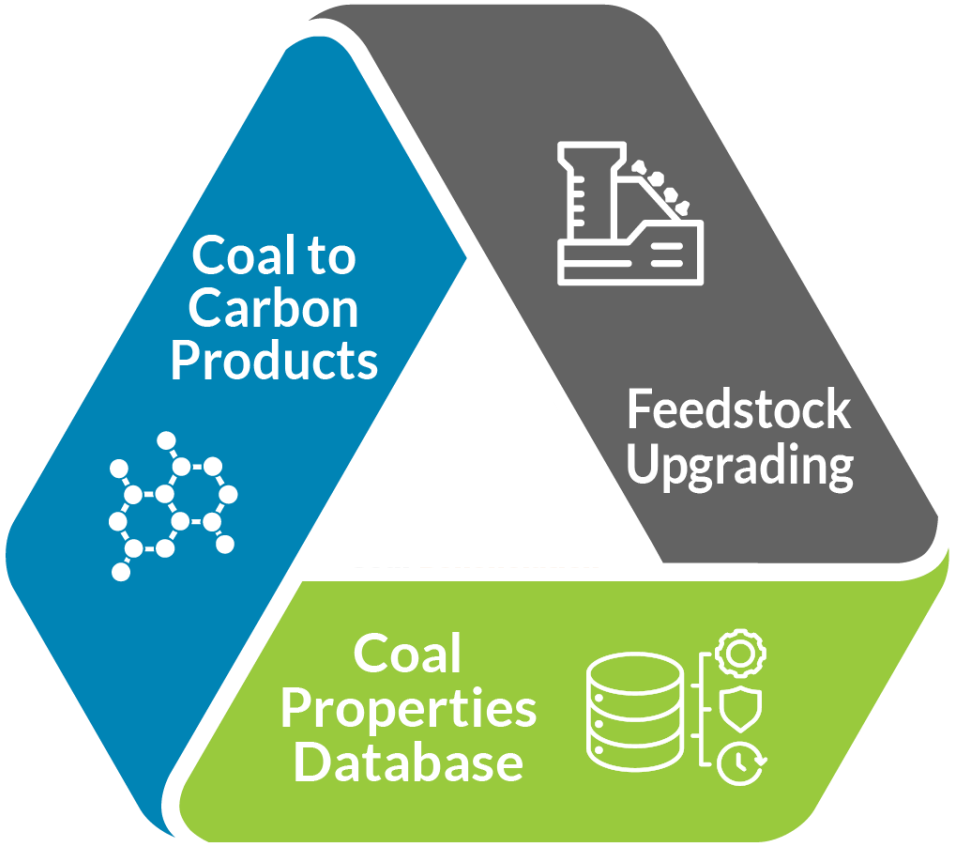
NETL's Advanced Coal Processing Program

Program Initiated 2018

Program Goals

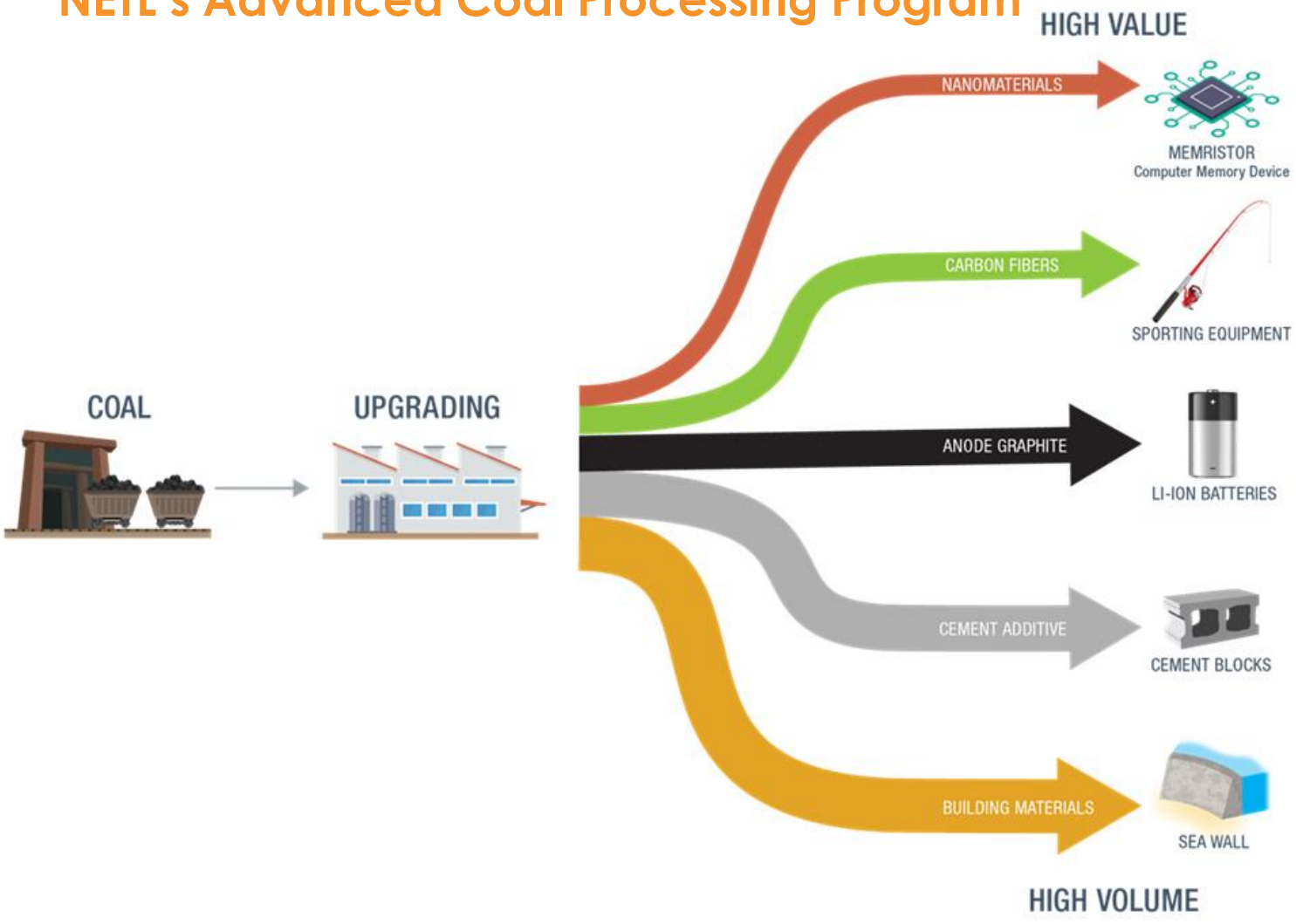
- Enhance the value and applications of domestic coal
- Develop new high-value products derived from domestic coal
- Advance laboratory and pilot-scale technologies
- Expand coal databases to inform domestic and global customers

Program Focus Areas



Expanding the Coal Value Chain

NETL's Advanced Coal Processing Program

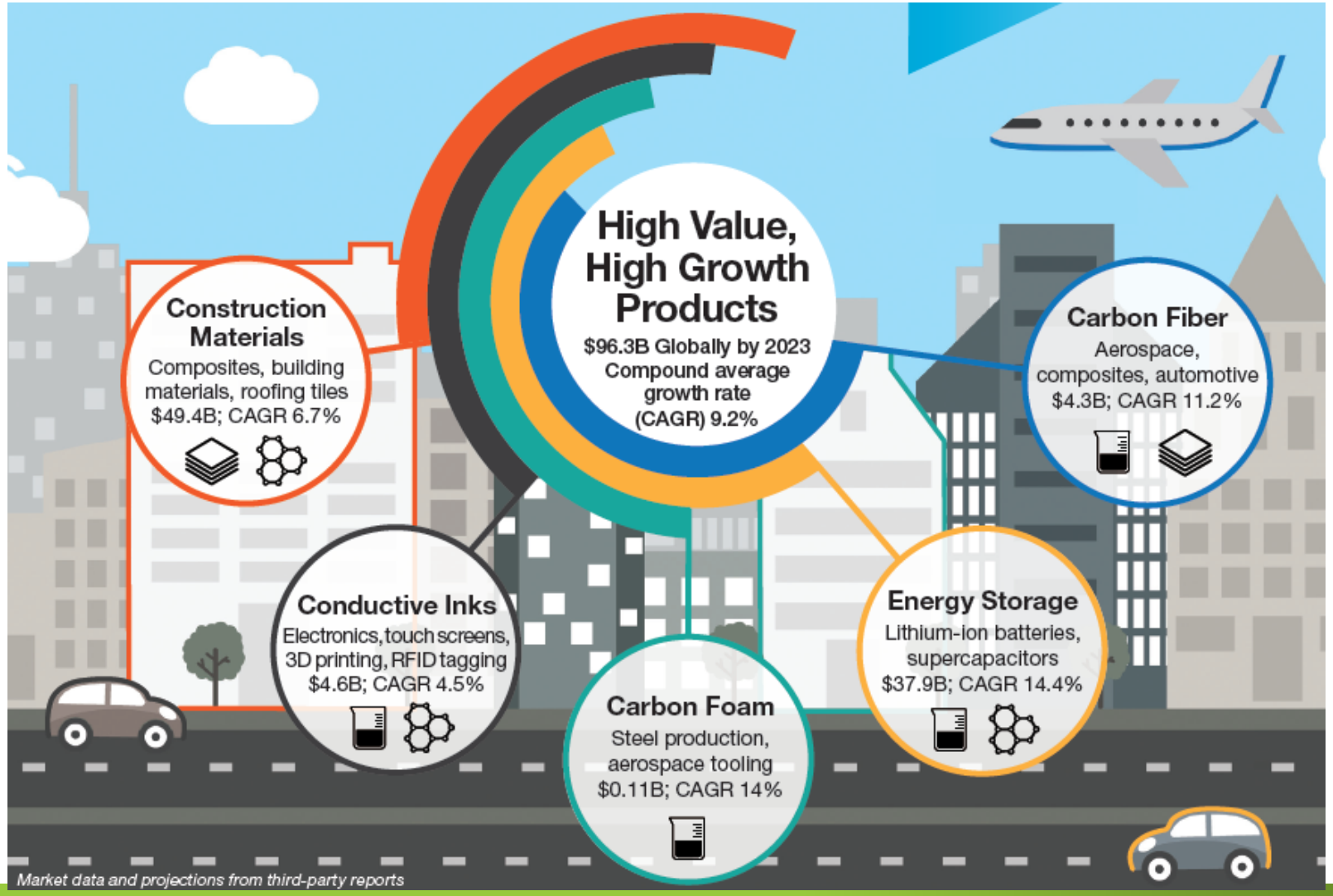


- Exciting opportunities to expand use of coal
- Advantages over other carbon-based feedstocks
  - Abundant and low cost
  - High-carbon density
  - Enables low cost, high-volume production of carbon materials
- Challenges
  - Optimizing product and process performance

Product and Application Market Potential

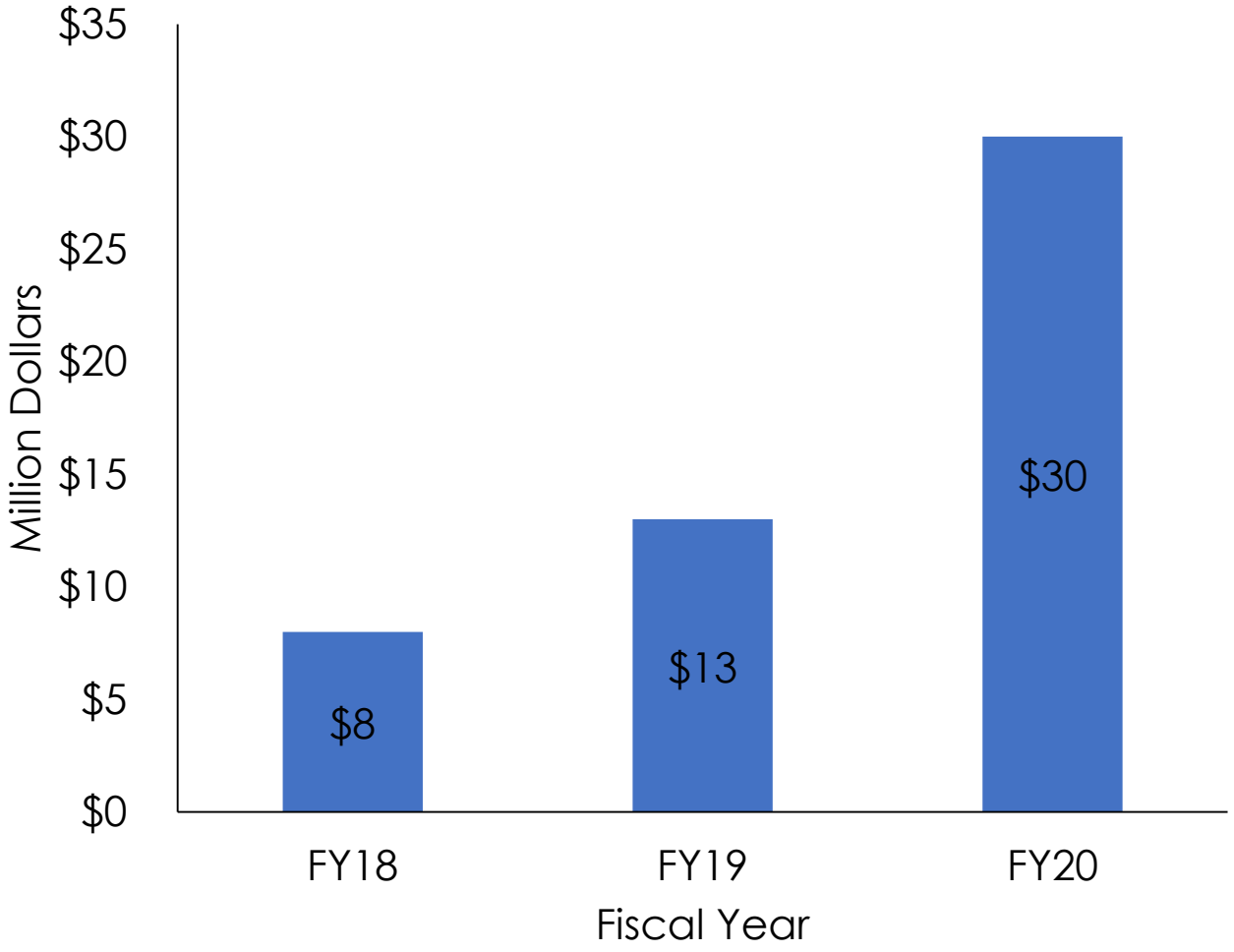
Advanced Coal Processing Program

- Program is focusing on high-value and high-growth products
- Current products and applications
  - $96.3B global market value by 2023
  - CAGR of 9.2%
- Tremendous potential for domestic coal



Advanced Coal Processing Budget History

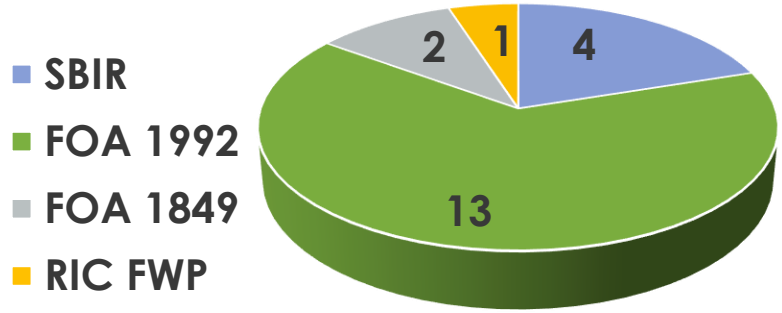
Program and Funding History



Funding Opportunity History

Funding Opportunity	Issue Date
SBIR-FOA-0001771: FY 2018 Phase 1 Release 2 High Value Products from Coal	11/29/2017
FOA-0001849: Novel Methods for Making Products from Carbon Dioxide or Coal	5/21/2018
SBIR-FOA-0001996: FY 2019 Phase 2 Release 2 High Value Products from Coal	12/20/2018
FOA-0001992: Maximizing the Coal Value Chain	3/4/2019
FOA-0002185: Coal-derived materials for building, infrastructure, and other applications	4/10/2020

Current Projects

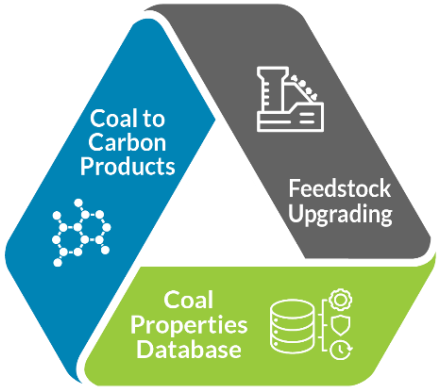


Current R&D Portfolio

Three new projects added in January 2020 for FOA 1992

Feedstock Upgrading
CarbonFuels
Minerals Refining Co

Coal Properties
NETL RIC



Building Materials
Semplastics
Ohio U
Battelle Memorial Inst
NETL RIC

Conductive Inks
Minus 100

3-D Printable Polymers
H Quest Vanguard

Carbon Fibers
Ramaco Carbon
U. of KY Research Fdn
Ramaco Carbon
Oak Ridge National Lab
University of Utah
NETL RIC

Silicon Carbide Foam
Touchstone Research

Nanomaterials
University of Illinois
Rice U
Massachusetts Institute of Technology
NETL RIC
University of North Dakota

Electrodes
George Washington U
Physical Sciences
Semplastics EHC, LLC

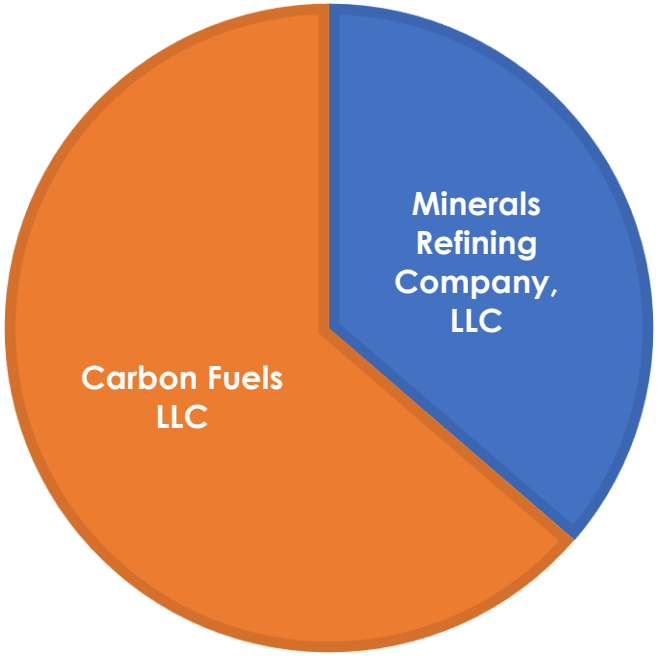
Feedstock Upgrading

Pilot Plant Testing and Development

Carbon Fuels LLC
FOA: 1849
Feb. 2019 – Jan. 2022
Total Award Value:
$3,166,443

The Novel Charfuel Coal Refining Process 18 Tpd Pilot Plant Project for Co-Producing an Upgraded Coal Product and Commercially Valuable Co-Products

TOTAL AWARD VALUE
~$4.97 MILLION



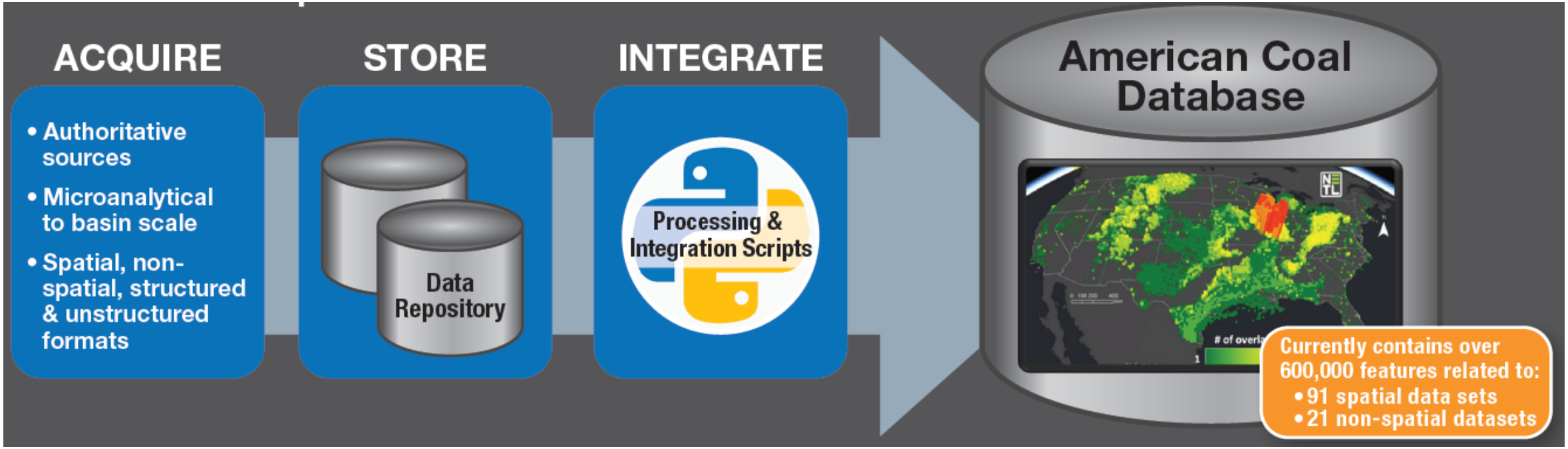
Minerals Refining Company, LLC
FOA: 1849
Feb. 2019 – Sept. 2021
Total Award Value:
$1,806,857

Pilot-Scale Testing of the Hydrophobic-Hydrophilic Separation Process to Produce Value-Added Products from Waste Coals

MRC
MINERALS REFINING COMPANY

Coal Database

American Coal Database (ACD) and Virtual Beneficiation Platform (COAL DATA)



An Authoritative "Smart" American Coal Database & Virtual Beneficiation Platform to Optimize Coal Sources for Efficient and Effective End Uses

- Provides coal property, geochemical, and infrastructure data to coal producers and consumers
- https://edx.netl.doe.gov/geocube/

Coal to Building Materials

Revolutionizing Sustainable Building and Construction Materials

- High-volume and high-value products for coal
- Opportunities for coal
  - Increase product performance
  - Increase building energy-efficiency
  - Reduce product cost
- Products improved from coal include
  - Carbon foam, roofing tiles, siding, decking, insulation, joists/studs, sheathing, tiles and carpet, and block
- Focus of FOA 2185 released in 2020

Coal to Building Materials

Program Focus Area: Carbon Products

Semplastics

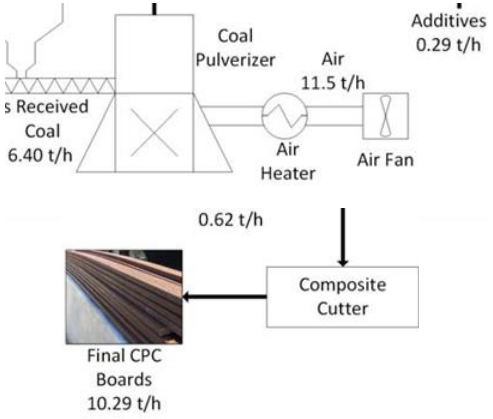
SBIR Grant
Phase 1 – 2018
Phase 2 – 2019

Coal-core composite (CCC) for roofing tiles and other products

Ohio U

FOA: 1992
Awarded Sept. 2019

Coal plastic composite (CPC) for decking boards and other products



Battelle

FOA: 1992
Awarded Sept. 2019

Coal to polyurethane (PU) foam (solid) products

NETL - RIC

FWP-1022432
Initiated 2018

Coal-derived graphene used as an additive in ordinary Portland cement

Coal to Carbon Fiber

Producing High-Performance Materials from Coal

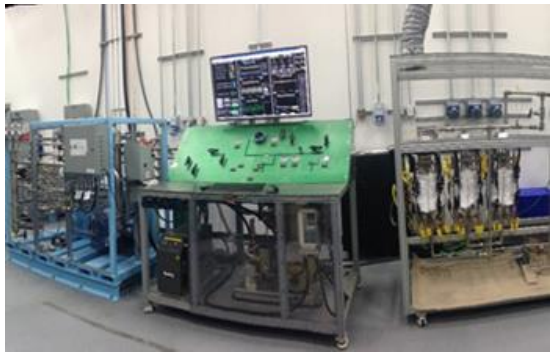
- Carbon fibers are strong light-weight materials
- Carbon Precursors include Polyacrylonitrile (PAN), Rayon, and coal tar pitch
- Program supports developments to enhance carbon fiber properties and production
- High carbon content, lower cost of coal tar pitch enable lower cost production

Coal to Carbon Fibers

Program Focus Area: Carbon Products

Ramaco Carbon
FOA: 1992
Awarded Sept. 2019

Raw coal feedstocks into pitch and carbon fibers

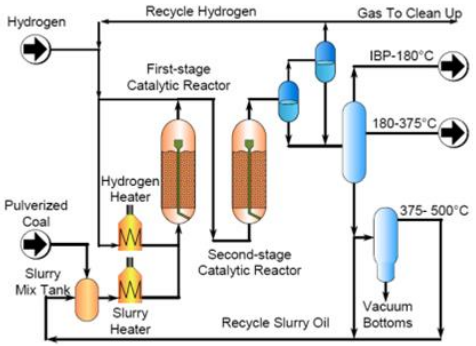


UKY
FOA: 1992
Awarded Sept. 2019

Melt spinning coal-derived pitch into fiber

Ramaco Carbon
FOA: 1992
Awarded Sept. 2019

High-quality carbon fiber precursor material



ORNL and UKY
COAL MAT Research Topic

Coal-derived Carbon Fiber for Thermo-Structural Applications

U. of Utah
FOA: 1992
Announced Jan. 2020

Isotropic and mesophase coal-tar pitch for carbon fiber production

Coal to Carbon Electrodes

Program Focus Area: Carbon Products

George Washington U
FOA: 1992
Awarded – Sept. 2019

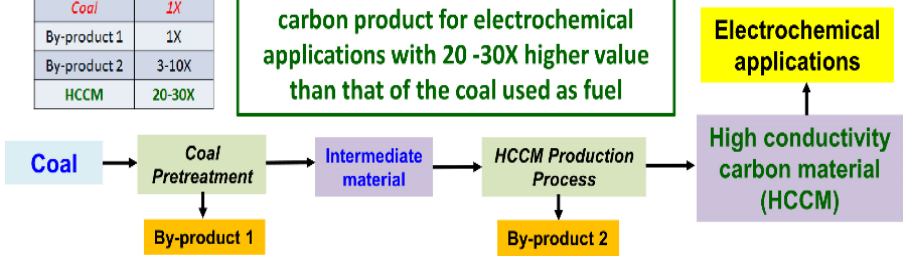
High value (Li-ion grade) "potato" graphite

Physical Sciences
SBIR Grant
Phase 1 – 2018
Phase 2 – 2019

High-conductivity carbon material (HCCM) for electrochemical applications

Stream	Rel. Price
Coal	1X
By-product 1	1X
By-product 2	3-10X
HCCM	20-30X

PSI process produces a high conductivity carbon product for electrochemical applications with 20 -30X higher value than that of the coal used as fuel



PSI's Innovative Process

Semplastics
FOA: 1992
Announced Jan. 2020

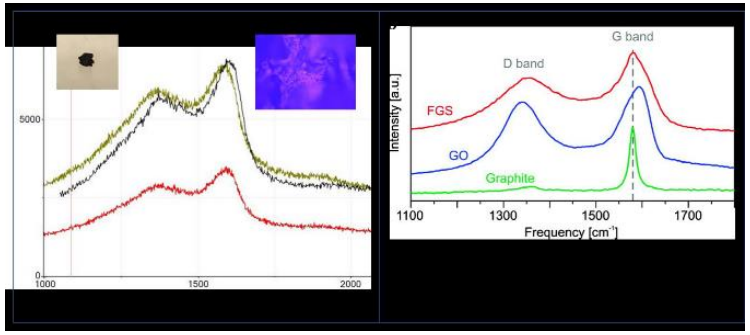
Composite material for use in lithium ion (Li-ion) battery anodes

Coal to Carbon Nanomaterials

Program Focus Area: Carbon Products

University of Illinois
FOA: 1992
Awarded – Sept. 2019

High-value carbon nanomaterials and carbon sorbents

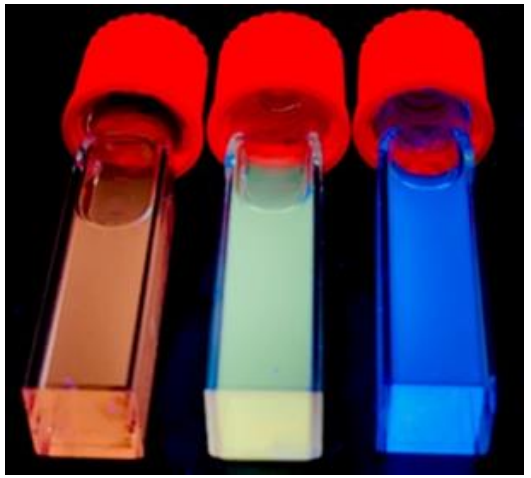


Rice U
FOA: 1992
Awarded – Sept. 2019

High-quality graphene

NETL - RIC
FWP-1022432
Initiated 2018

Coal-based Carbon Nanomaterials



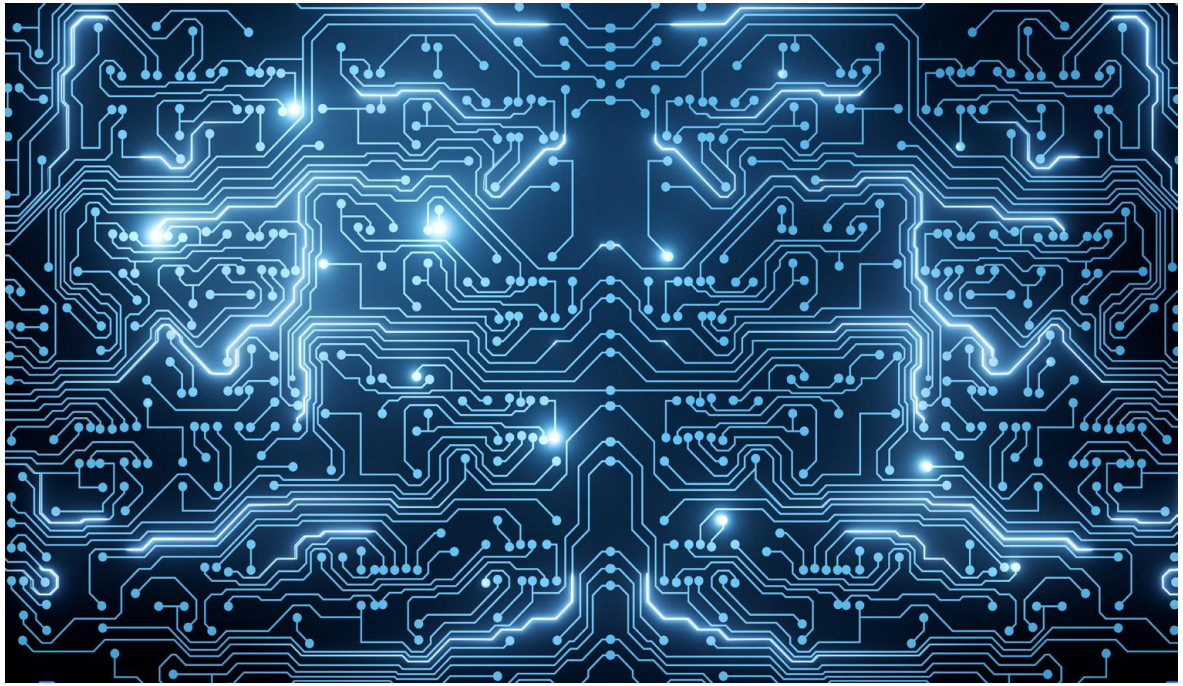
U. North Dakota
FOA: 1992
Announced Jan. 2020

Laboratory-Scale Coal-Derived Graphene

Coal to Conductive Inks

Expanding Viable High-value, High-growth Markets for Coal

- Inks infused with conductive materials
- Enables printing of electrically conductive surfaces
- Facilitates production of flexible, stretchable, potentially self-healing electrical circuits
- Conductive carbon materials produced from domestic coal enables lower production costs



Conductive Inks, 3D Printable Polymers, SiC Foam

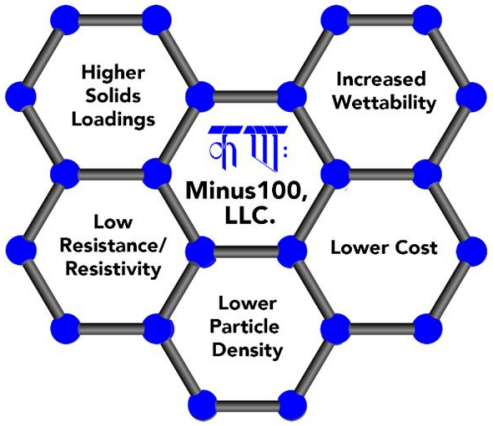
Program Focus Area: Carbon Products

Conductive Inks

Minus 100

SBIR Grant
Phase 1 – 2018
Phase 2 – 2019

New methods of manufacturing highly conductive ink pigments

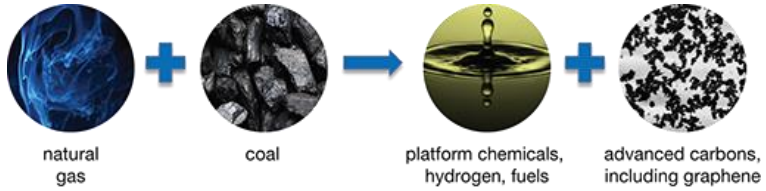


3-D Printable Polymers

H Quest Vanguard

FOA: 1992
Awarded – Sept. 2019

Carbon and graphitic materials for industrial electrode applications and advanced 3-D printable carbon polymer composites

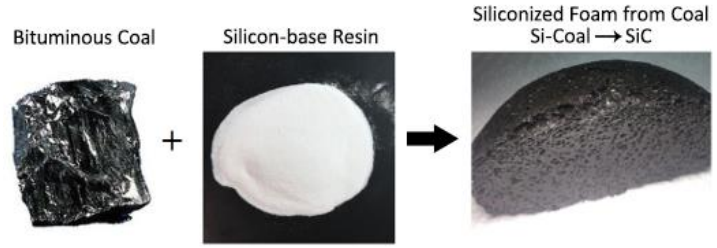


Silicon Carbide Foam

Touchstone Research Lab

SBIR Grant
Phase 1 – 2018
Phase 2 – 2019

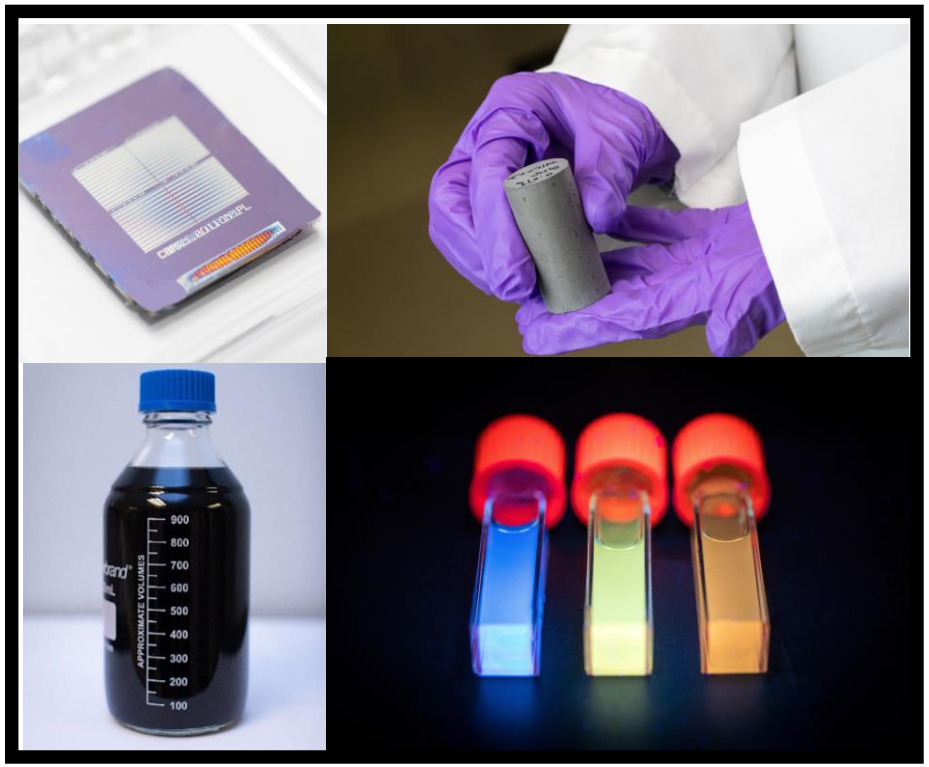
New silicon carbon (SiC) foam utilizing coal feedstock for s-CO_2 turbine operation



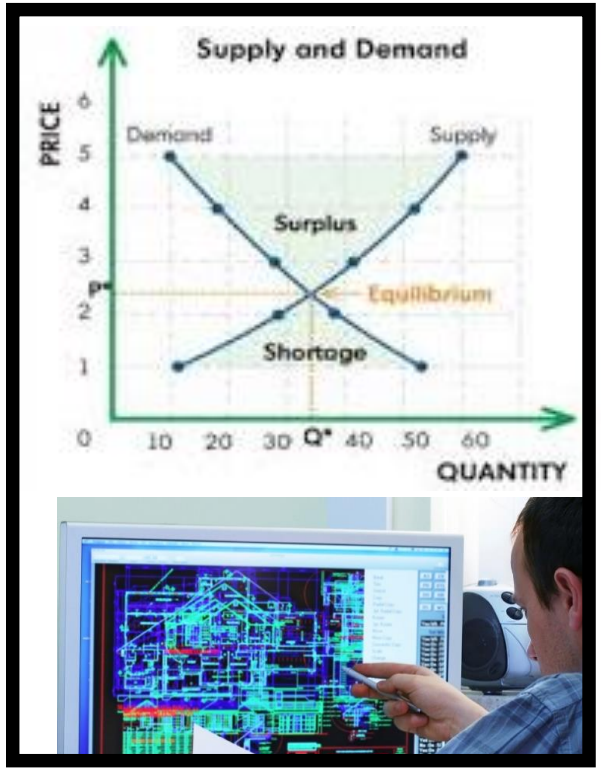
NETL-RIC's Coal to Products Research

NETL's Research Innovation Center

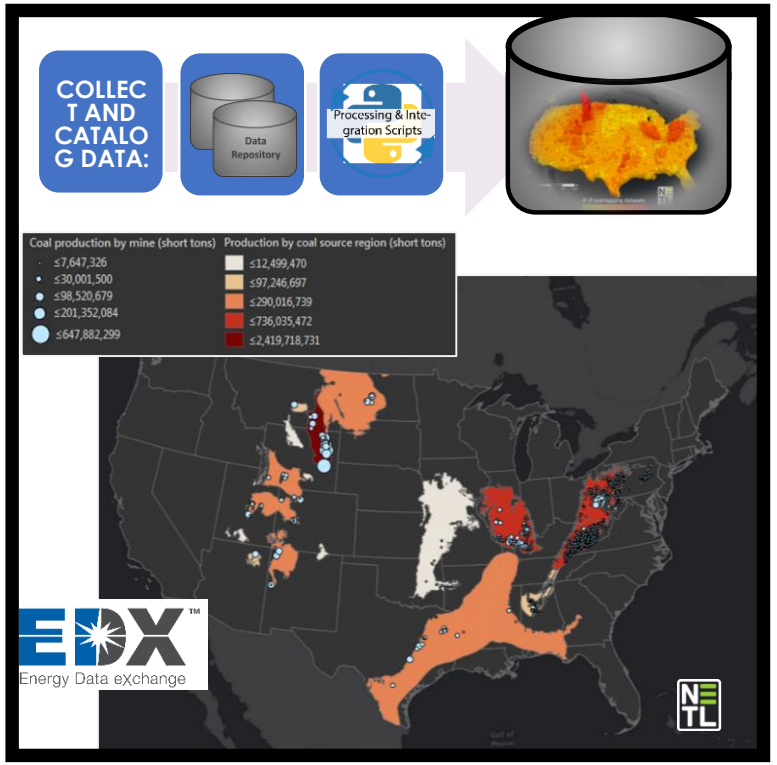
Materials Discovery & Design



Market, Process, & Environmental Analysis

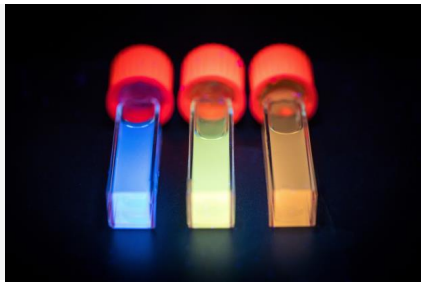


American Coal Database



Recent Accomplishments

NETL patent-pending technology converts coal into single-atom-thick carbon materials such as graphene



NETL coal-derived additive enables stronger and more durable cement at reduced cost

Coal-based nanomaterials manufactured at NETL are used to make computer memory devices

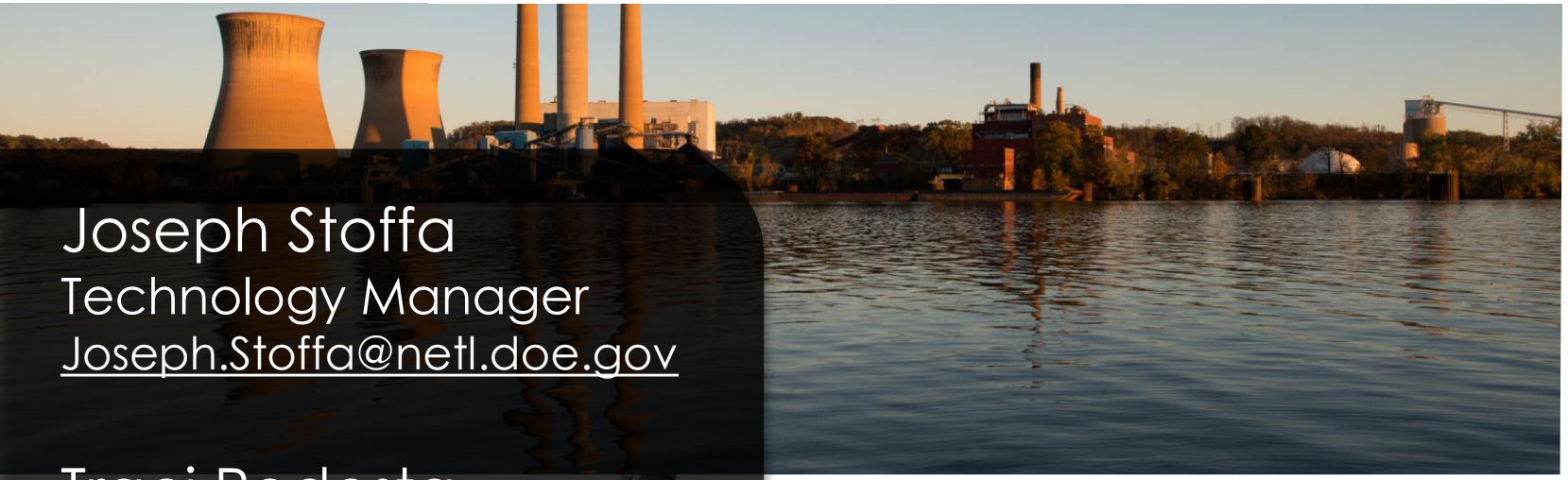
Takeaways

- Exciting opportunities exist to expand the coal value chain
- New program – Initiated in 2018
- Lab scale through pilot-scale development

Stakeholder involvement essential for transition of technologies to industry

Contacts

https://netl.doe.gov/Advanced_Coal_Processing



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